

a further conductive film formed below said insulating film; and
a contact hole formed within said pad trench to electrically connect said conductive film to said further conductive film, wherein said contact hole and said further conductive film substantially suppress an increase in electrical resistance in said pad trench due to formation of said protrusion.

REMARKS

The final Office Action mailed October 9, 2001 and the references cited therein have been carefully considered. Claim 8 has been amended to further clarify the subject matter Applicants regard as the invention.

No new matter has been added to the claims, as amended. Support for this Amendment is found generally within the specification, claims, and drawings, as filed. As a result of this Amendment taken together with the remarks set forth below, it is respectfully submitted that pending Claims 1-6 and 8-13 are now before the Examiner in condition for allowance.

Claims 1-6 and 8-13 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,602,423 to Jain (*Jain*) in view of U.S. Patent No. 5,923,088 to Shiue, et al. (*Shiue*). Specifically, the Examiner indicates that *Jain* discloses a damascene interconnection that includes a conductor-filled trench 64 and insulating pillars 50. The Examiner further states that Figure 10 shows a plan view of a pillared pad 55, through which multiple protrusions are dispersed, and that Figure 6 shows a damascene interconnection formed by a patterned insulating layer 22 over a substrate 20.

In addition, the Examiner states that conducting segments 32, 44, and 46 lie between insulating pillars 38 and that column 5, lines 34-45 indicate that the incorporation of insulating pillars divides a wider conductor, and thus minimizes dishing. However, the

Examiner concedes that *Jain* does not disclose a contact hole formed within the pad trench to electrically connect a conductive film to another conductive film below the insulating film, wherein the contact hole and the additional conductive film substantially suppress an increase in electrical resistance in the pad trench due to formation of the protrusions.

However, the Examiner indicates that *Shiue* describes a bond pad structure that includes a third metal pad 30, second via plugs 36, and a second metal pad 32 connected to the third metal pad through the second via plugs. The Examiner further states that it would have been obvious to one of ordinary skill to include the second via plugs and second metal pad in the invention described in *Jain* to connect the conducting segments to further integration within the substrate.

The Examiner also indicates that the limitation regarding suppression of an increase in electrical resistance in the pad trench due to formation of the protrusions does not differentiate the claimed apparatus from prior art satisfying the claimed structural limitations. Regarding Claims 4 and 11, the Examiner states that *Jain* describes many other insulating patterns that produce the same effect, that is, the reduction of dishing by the narrowing of wide trenches.

The subject invention is directed to a damascene interconnection, which includes an interconnection trench, a protrusion, a conductive film, and a contact hole. The interconnection trench is formed in the insulating film and a pad trench communicating therewith. The protrusion is formed by a portion not removed of the insulating film in the pad trench to decrease a substantial opening area of the pad trench. The conductive film is buried in the interconnection trench and the pad trench. The contact hole is formed within the pad trench and electrically connects the conductive film to a further conductive film formed below the insulating film, wherein the contact hole and the further conductive film substantially suppress an increase in electrical resistance in the pad trench due to formation of the protrusion, as now defined by Claim 1.

The subject invention is also directed to a semiconductor device, which includes a semiconductor substrate, an insulating film formed on the semiconductor substrate, an interconnection trench formed on the insulating film, a pad trench formed on the insulating film, a protrusion, a conductive film, a further conductive film, and a contact hole. The protrusion reduces the opening area of the pad trench, and the conductive film is buried in the interconnection trench and the pad trench. The further conductive film is formed below the insulating film, and the contact hole is formed within the pad trench to electrically connect the conductive film to the further conductive film, wherein the contact hole and the further conductive film substantially suppress an increase in electrical resistance in the pad trench due to formation of the protrusion, as now defined by amended Claim 8.

Jain relates to a semiconductor device that uses an embedded pillar to prevent damage, such as dishing, smearing, and overetching, to damascene connectors during fabrication, particularly where such conductors are relatively large. The device includes an insulating layer formed on a substrate having a planar upper surface with a plurality of channels. The channel includes contiguous narrow channel segments enclosing one or more pillars having a top surface that is coplanar with the upper surface of the insulating layer. In one embodiment, the pillar is formed integrally as part of the insulating layer.

In an alternative embodiment, the pillar is formed from an additional insulating or conductive layer. However, *Jain* does not disclose contact holes at the bottom of the conductive film to enable division of the conductive film into non-contiguous portions or areas, as defined by Claims 1 and 8; disclosed on page 8, line 23 through page 10, line 11 of the specification; and shown in Figures 10-13.

Shiue relates to a bond pad structure that is intended to provide for reliable interconnection between the bonding structure and the next level of circuit integration. The bond pad uses three metal pads separated by layers of dielectric, through which via plugs are formed. The periphery of the via plugs form a square rotated 45° with respect to the square metal pads. The second via plugs 36, as shown on Figure 3, are not located above the first

via plugs 38, but rather are located directly above the spaces between the first via plugs 38. The invention is intended to increase tensile and shear strength, which minimizes peeling and cracking.

The Examiner states that the limitation "wherein said contact hole and said further conductive film substantially suppress an increase in electrical resistance in said pad trench due to formation of said protrusion" does not define any structure, and thus cannot serve to distinguish the subject invention from the cited references. It is submitted that older decisions of the Circuit Court of Appeals (CCPA) appeared to disapprove of the use of functional language. For instance, in *In re: Mason*, the CCPA stated that:

Claims 10 and 11 also include a functional statement as to what happens when one of the web portions is torn transversely along a tearing line. That statement, however, does not define any structure and accordingly cannot serve to distinguish claims 10 and 11, which are not process claims, from the reference. *In re Mason*, 244 F.2d 733, 114 USPQ 129 (citing *In re Statmann*, 146 F.2d 290, 64 USPQ 245 (C.C.P.A. 1944); *In re Lippold*, 176 F.2d 932, 83 USPQ 120 (C.C.P.A. 1949)).

More recently, however, the CCPA gave patentable weight to functional claim limitations. For example, in *In re Swinehart*, 439 F.2d 210, 169 USPQ 226 (C.C.P.A. 1971), the CCPA stated the following:

We take the characterization "functional", as used by the Patent Office and argued by the parties, to indicate nothing more than the fact that an attempt is being made to define something (in this case, a composition) by what it does rather than by what it is (as evidenced by specific structure or material, for example). In our view, there is nothing intrinsically wrong with the use of such a technique in drafting patent claims. Indeed we have even recognized in the past the practical necessity for the use of functional language. *In re Swinehart*, 439 F.2d 210, 169 USPQ 228-229 (C.C.P.A. 1971).

Therefore, it is respectfully submitted that functional limitations must not be deleted before determining obviousness. For example, in *In re Land*, 368 F.2d 866, 151 USPQ 621 (C.C.P.A. 1966), the claim at issue (Claim 70) related broadly to a complete photographic unit including a mono-pack, an image-receiving layer, and a connecting means. The photographic unit developed the image using a single liquid composition. In addition, Claim 70 recited that:

Said color-providing substances associated with at least the inner photosensitive emulsion layers are *adapted to be rendered diffusible* in said liquid composition *only after at least substantial development* of the next outermost photosensitive . . . layer has occurred. *In re Land*, 368 F.2d 866, 151 USPQ 635 (C.C.P.A. 1966).

The CCPA noted that the italicized portions of Claim 70 were functional, but held the claim patentable over the prior art in view of the functional limitations. As stated by the CCPA:

It is true that the italicized portions [of claim 70] are "functional" but we do not regard that as good ground to give them "no weight" in view of the third paragraph [currently sixth paragraph] of 35 U.S.C. 112. We give them weight and with this limitation we think claims 70 and 71 are limited to deferred diffusion *built into the structure recited*, thereby being limited to the actual invention disclosed and hence allowable for the same reasons given by the board . . . *In re Land*, 368 F.2d 866, 151 USPQ 635-36 (C.C.P.A. 1966).

In re Mills, 916 F.2d 680, 16 USPQ 2d 1430 (Fed. Cir. 1990) also involved claims with functional limitations that were assigned patentable weight by the Federal Circuit. In *Mills*, the claim at issue recited the following:

6. Apparatus for producing an aerated cementitious composition, comprising: . . .
drive motor means connected through gearbox means providing a pumping capacity of the pump means greater than the feed rate of the ingredients to the mixing

chamber provided by the feed means, such that in operation air is drawn into the mixing chamber, and entrained in the mixed ingredients.

The Examiner rejected the claim as obvious because the differences between the claim and the cited references lay “solely” in the functional language of the claim. *Id.* at 1432.

On appeal, the Federal Circuit reversed the Examiner’s decision. The court specifically acknowledged that the difference between the claim and the prior art lay specifically in the functional limitations of the “pump means and the feed means providing a pumping capacity . . . such that in operation air is drawn into the mixing chamber, and air [is] entrained in the mixed ingredients.” *Id.* Nevertheless, the Federal Circuit held the claim nonobvious over the prior art based on the functional limitations. *Id.* at 1433. Thus, *Mills* teaches that patentable weight must be afforded to functional limitations even if the functional limitations are the only limitations that are nonobvious over the prior art.

There is ample additional precedent to establish that functional limitations are appropriate in claims and should be afforded patentable weight in the determination of obviousness. For instance, *In re Ludtke*, 441 F.2d 660, 169 USPQ 563, 566 (C.C.P.A. 1971) (“We agree with the Patent Office that the spatial separation between the panels is recited in functional language; however, as we said recently in *In re Swinehart* [439 F.2d 210, 169 USPQ 226 (C.C.P.A. 1971)], . . . there is nothing intrinsically wrong with the use of such claim language.”); *In re Atwood*, 354 F.2d 365, 148 USPQ 203, 210 (C.C.P.A. 1966) (“We have here a combination claim and the limitations ignored by the board as use limitations we think are functional expressions which must be given weight.”); *In re Bisley*, 197 F.2d 355, 94 USPQ 80, 83 (C.C.P.A. 1952) (It appears to us that these claims define the angle of the pivot pin with respect to component elements of the mixer, albeit by geometrical language, in such a manner that the pin is structurally located, by the terms of these claims, at a substantial angle with respect to identified horizontal and vertical datum planes and within

that range of angularity which will achieve appellant's desired novel result. Definite limitations in a claim should not be ignored or construed out of the claim.).

In addition, *Ex parte Sherman*, 45 USPQ 532, 534 (Pat. Off. Bd. App. 1939), stated the following:

While the claims contain numerous functional statements, these statements seem to be used for the purpose of clearly defining or differentiating elements which have been positively included in the claims. We see no objection to the use of the functional statement to define an element, even where the element may be set forth by the term "means."

Accordingly, the precedent summarized above clearly indicates that functional limitations are to be given patentable weight even in situations where it is only the functional limitation that distinguishes over the prior art.

It is submitted that since *Shiue* is directed to solving the problem of providing adequate tensile and shear strength in bonding pads, the method described in *Shiue* is drawn from a non-analogous application in a crowded art, which would not reasonably be considered pertinent to the particular problem with which the inventors of the subject invention were involved and would not have commended itself to the inventors' attention in considering the relevant problem of suppressing electrical resistance due to the formation of protrusions in the pad trench. Precedent for this position is provided in *In re Wood*, 599 F.2d 1032, 202 USPQ 171, 174 (C.C.P.A. 1979), as follows:

...we only presume knowledge from those arts reasonably pertinent to the particular problem with which the inventor was involved. The rationale behind this rule precluding rejections base on combination of teachings of references from nonanalogous arts is the realization that an inventor could not possibly be aware of every teaching in every art.

In re Clay, 966 F.2d 656, 23 USPQ 2d 1058, 1060-61 (Fed. Cir. 1992) further states the following:

[a] reference is reasonably pertinent if...it is one which, because of the matter with which it deals, logically would have commended itself to the inventor's attention in considering his problem...If a reference disclosure has the same purpose as the claimed invention, the reference relates to the same problem...[I]f it is directed to a different purpose, the inventor would accordingly have had less motivation or occasion to consider it.

Thus, it is submitted that semiconductor fabrication is a crowded art and that *Jain* and *Shiue* represent non-analogous art since *Jain* relates to dishing and *Shiue* relates to increasing sheer and tensile strength in bonding pads. In addition, there is no suggestion in either reference to combine the non-analogous arts of *Jain* and *Shiue* in the manner proposed by the Examiner.

Even if the cited references were combined, the combination would not teach or suggest a contact hole connecting the top metalization layer in *Shiue* between insulating pillars, as described in *Jain*, to the next lower conductive layer in *Shiue* to suppress increases in resistance, as defined by Claims 1 and 8 of the subject invention. The problem of increased resistance due to the formation of pillars is neither recognized nor addressed in either of the cited references. As a result, the semiconductor device described in *Jain* is likely to experience substantial increases in resistance and discontinuities caused by the pillar pattern having non-contiguous conductive film portions.

It is further submitted that the Examiner may not consider the discovery of a problem, such as the increase in resistance due to the formation of protrusions in a pad trench, to satisfy the requirements of obviousness since all that is considered is the incremental advance. However, the courts have made it clear that the discovery of the problem is to be considered in determining patentability, as indicated in *In re Nomiya*, 509 F.2d 566, 184 USPQ 607, 612 (C.C.P.A 1975):

It should not be necessary for this court to point out that a patentable invention may lie in the discovery of the source of a problem even though the remedy may be obvious once the source of the problem is identified. This is part of the "subject matter as a whole" which should always be considered in determining the obviousness of an invention under 35 U.S.C. 103.

Applicants respectfully submit that Claims 2-6, which depend from Claim 1, and Claims 9-13, which depend from Claim 8, are patentable over the art of record by virtue of their dependency from Claims 1 and 8, respectively, which are believed patentable for the reasons set forth above. Further, Applicants submit that Claims 2-6 and Claims 9-13 define additional patentable subject matter in their own right. Therefore, it is respectfully requested that the rejection of Claims 1-6 and 8-13 under 35 U.S.C. § 103(a) be reconsidered and withdrawn.

In view of the foregoing Amendment and remarks, entry of the amendments to Claim 8, favorable consideration of the amendments to Claim 8, favorable reconsideration of Claims 1-6 and 9-13, and allowance of pending Claims 1-6 and 8-13 are respectfully and earnestly solicited.

Respectfully submitted,



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VERSION OF AMENDMENT WITH MARKINGS TO SHOW CHANGES MADE
IN THE CLAIMS:

Please amend Claim 8 by rewriting the same as follows:

8. (Twice Amended) A semiconductor device, comprising:
- a semiconductor substrate;
 - an insulating film formed on said semiconductor substrate;
 - an interconnection trench formed on said insulating film and communicating with a semiconductor element;
 - a pad trench formed on said insulating film and communicating with said interconnection trench;
 - a protrusion formed by a portion [of] not removed of said insulating film in said pad trench and reducing a substantial opening area of said pad trench;
 - a conductive film buried in said interconnection trench and said pad trench;
 - a further conductive film formed below said insulating film; and
 - a contact hole formed within said pad trench to electrically connect said conductive film to said further conductive film, wherein said contact hole and said further conductive film substantially suppress an increase in electrical resistance in said pad trench due to formation of said protrusion.